

CLAIMS

What is claimed is:

- 1 1. A method for improving a transmission of a free-space optical
2 communications signal passing through a window having a first imperfect
3 surface including a plurality of non-flat surface voids, comprising:
4 applying a void-filling material in a non-solid form to the first
5 imperfect surface so as to fill any non-flat surface voids on the first
6 imperfect surface in an area through which the optical communications
7 signal is to pass; and
8 curing the void-filling material into a solid form such that an outside
9 surface of the void-filling material adjacent to the first imperfect surface is
10 substantially perfectly planar,
11 wherein the void-filling material is selected to have an index of
12 refraction that substantially matches an index of refraction for the window
13 at an optical wavelength corresponding to the free-space optical
14 communication signal. .

- 1 2. The method of claim 1, wherein the void-filling material
2 comprises a liquid that is sprayed over the first imperfect surface.

1 3. The method of claim 1, wherein the void-filling material
2 comprises a gel that is applied to the first imperfect surface using a brush
3 or roller.

1 4. The method of claim 1, wherein the wavelength of the free-
2 space optical communications signal is from 700 to 1700 nanometers.

1 5. The method of claim 1, wherein the window further comprises a
2 second imperfect surface including a plurality of non-flat surface voids,
3 further comprising:

4 applying the void-filling material to the second imperfect surface so
5 as to fill any non-flat surface voids on the second imperfect surface in an
6 area through which the optical communications signal is to; and

7 curing the void-filling material into a solid form such that an outside
8 surface of the void-filling material adjacent to the second imperfect
9 surface is substantially perfectly planar.

1 6. A method for improving a transmission of a free-space optical
2 communications signal passing through a window having a first imperfect
3 surface including a plurality of non-flat surface voids, comprising:

4 applying a void-filling material to the first imperfect surface so as to
5 fill any non-flat surface voids on the first imperfect surface in an area
6 through which the optical communications signal is to pass; and

7 mounting a substantially perfect optically translucent plate having
8 an outside surface that is substantially perfectly planar to the first
9 imperfect surface of the window so as to capture the void-filling material
10 between an inside surface of the substantially perfect optically translucent
11 plate and the first imperfect surface of the window,
12 wherein the void-filling material is selected to have an index of
13 refraction that substantially matches an index of refraction for the window
14 at an optical wavelength corresponding to the free-space optical
15 communication signal.

1 7. The method of claim 6, wherein the void-filling material
2 comprises a liquid.

1 8. The method of claim 6, wherein the void-filling material
2 comprises a gel.

1 9. The method of claim 6, wherein the wavelength of the free-
2 space optical communications signal is from 700 to 1700 nanometers.

1 10. The method of claim 6, wherein the substantially perfect
2 optically translucent plate is mounted to the first imperfect surface of the
3 window by applying an adhesive between a peripheral area of the

4 substantially perfect optically translucent plate and an adjacent area in the
5 first imperfect surface of the window.

1 11. The method of claim 10, wherein the void-filling material is
2 captured between the inside surface of the substantially perfect optically
3 translucent plate and the first imperfect side of the window by:
4 applying the adhesive to a peripheral area of the inside surface of
5 the substantially perfect optically translucent plate;
6 applying the void-filling material to an area contained within the
7 peripheral area on the inside surface of the substantially perfect optically
8 translucent plate; and
9 rapidly rotating the substantially perfect optically translucent plate
10 and holding it so its inside surface mates with the first imperfect surface of
11 the window until the adhesive is able to hold the substantially perfect
12 optically translucent plate in place.

1 12. The method of claim 10, wherein the adhesive comprises an
2 ultra-violet (UV) curable adhesive that rapidly cures in response to
3 application of UV light.

1 13. The method of claim 6, wherein the substantially perfect
2 optically translucent plate comprises a type of glass.

1 14. The method of claim 6, wherein the substantially perfect
2 optically translucent plate comprises a plastic.

1 15. The method of claim 6, wherein the substantially perfect
2 optically translucent plate includes a protective coating on its outside
3 surface to protect the outside surface from environmental damage.

1 16. The method of claim 6, wherein the substantially perfect
2 optically translucent plate has a planar cavity defined in its inside surface
3 and wherein the void-filling material is captured between the inside
4 surface of the substantially perfect optically translucent plate and the first
5 imperfect side of the window by:
6 mounting a peripheral area of the substantially perfect optically
7 translucent plate to the first imperfect surface of the window; and
8 inserting the void-filling material into the cavity.

1 17. The method of claim 6, wherein the window further comprises
2 a second imperfect surface including a plurality of non-flat surface voids,
3 further comprising:
4 applying the void-filling material to the second imperfect surface so
5 as to fill any non-flat surface voids on the second imperfect surface in an
6 area through which the optical communications signal is to pass; and

7 mounting a second substantially perfect optically translucent plate
8 having an outside surface that is substantially perfectly planar to the
9 second imperfect surface of the window so as to capture the void-filling
10 material between an inside surface of the second substantially perfect
11 optically translucent plate and the second imperfect surface of the
12 window.

1 18. A method for improving a transmission of a free-space optical
2 communications signal passing through a window having a first imperfect
3 surface including a plurality of non-flat surface voids, comprising:
4 applying a void-filling material to the first imperfect surface so as to
5 fill any non-flat surface voids on the first imperfect surface in an area
6 through which the optical communications signal is to pass; and
7 covering the void-filling material with a flexible optically translucent
8 sheet of material so as to capture the void-filling material between an
9 inside surface of the flexible optically translucent sheet of material and the
10 first imperfect surface of the window,
11 wherein the void-filling material is selected to have an index of
12 refraction that substantially matches an index of refraction for the window
13 at an optical wavelength corresponding to the free-space optical
14 communication signal.

1 19. The method of claim 18, wherein the void-filling material
2 comprises a liquid.

1 20. The method of claim 18, wherein the void-filling material
2 comprises a gel.

1 21. The method of claim 18, wherein the window further comprises
2 a second imperfect surface including a plurality of non-flat surface voids,
3 further comprising:
4 applying the void-filling material to the second imperfect surface so
5 as to fill any non-flat surface voids on the second imperfect surface in an
6 area through which the optical communications signal is to pass; and
7 covering the void-filling material that is applied to the second
8 imperfect surface with a second flexible optically translucent sheet of
9 material so as to capture the void-filling material between an inside
10 surface of the second flexible optically translucent sheet of material and
11 the second imperfect surface of the window.

1 22. An apparatus for improving a transmission of a free-space
2 optical communications signal passing through a window having a first
3 imperfect surface including a plurality of non-flat surface voids,
4 comprising:

5 a void-filling material that is applied in a non-solid form to the first
6 imperfect surface so as to fill any non-flat surface voids in an area on the
7 first imperfect surface through which the optical communications signal is
8 to pass and cured into a solid form such that an outside surface of the
9 void-filling material adjacent to the first imperfect surface is substantially
10 perfectly planar,

11 wherein the void-filling material is selected to have an index of
12 refraction that substantially matches an index of refraction for the window
13 at an optical wavelength corresponding to the free-space optical
14 communication signal.

1 23. The apparatus of claim 22, wherein the wavelength of the free-
2 space optical communications signal is from 700 to 1700 nanometers.

1 24. The apparatus of claim 22, wherein the window further
2 comprises a second imperfect surface including a plurality of non-flat
3 surface voids to which the void-filling material is also applied so as to fill
4 any non-flat surface voids in an area on the second imperfect surface
5 through which the optical communications signal is to pass, said void-
6 filling material being cured into a solid form such that an outside surface
7 of the void-filling material adjacent to the second imperfect surface is
8 substantially perfectly planar.

1 25. An apparatus for improving a transmission of a free-space
2 optical communications signal passing through a window having a first
3 imperfect surface including a plurality of non-flat surface voids,
4 comprising:
5 a void-filling material that is applied to the first imperfect surface so
6 as to fill any non-flat surface voids in an area on the first imperfect surface
7 through which the optical communications signal is to pass; and
8 a substantially perfect optically translucent plate having an outside
9 surface that is substantially perfectly planar, which is mounted to the first
10 imperfect surface of the window so as to capture the void-filling material
11 between an inside surface of the substantially perfect optically translucent
12 plate and the first imperfect surface of the window,
13 wherein the void-filling material is selected to have an index of
14 refraction that substantially matches an index of refraction for the window
15 at an optical wavelength corresponding to the free-space optical
16 communication signal.

1 26. The apparatus of claim 25, wherein the void-filling material
2 comprises a liquid.

1 27. The apparatus of claim 25, wherein the void-filling material
2 comprises a gel.

1 28. The apparatus of claim 25, wherein the wavelength of the free-
2 space optical communications signal is from 700 to 1700 nanometers.

1 29. The apparatus of claim 25, wherein the substantially perfect
2 optically translucent plate is mounted to the first imperfect surface of the
3 window by means of an adhesive that is disposed between a peripheral
4 area of the substantially perfect optically translucent plate and the first
5 imperfect surface of the window.

1 30. The apparatus of claim 29, wherein the adhesive comprises an
2 ultra-violet (UV) curable adhesive that rapidly cures in response to
3 application of UV light.

1 31. The apparatus of claim 25, wherein the substantially perfect
2 optically translucent plate comprises a type of glass.

1 32. The apparatus of claim 25, wherein the substantially perfect
2 optically translucent plate comprises a plastic.

1 33. The apparatus of claim 25, wherein the substantially perfect
2 optically translucent plate includes a protective coating on its outside
3 surface to protect the outside surface from environmental damage.

1 34. The apparatus of claim 25, wherein the substantially perfect
2 optically translucent plate has a planar cavity defined in its inside surface
3 and wherein the void-filling material is captured between the inside
4 surface of the substantially perfect optically translucent plate and the first
5 imperfect side of the window by inserting the void-filling material into the
6 cavity.

1 35. The apparatus of claim 25, wherein the window further
2 comprises a second imperfect surface including a plurality of non-flat
3 surface voids to which the void-filling material is also applied so as to fill
4 any non-flat surface voids in an area on the second imperfect surface
5 through which the optical communications signal is to pass, further
6 comprising:
7 a second substantially perfect optically translucent plate having an
8 outside surface that is substantially perfectly planar, which is mounted to
9 the second imperfect surface of the window so as to capture the void-
10 filling material between an inside surface of the second substantially
11 perfect optically translucent plate and the second imperfect surface of the
12 window.

1 36. An apparatus for improving a transmission of a free-space
2 optical communications signal passing through a window having a first

3 imperfect surface including a plurality of non-flat surface voids,
4 comprising:
5 a void-filling material that is applied to the first imperfect surface so
6 as to fill any non-flat surface voids in an area on the first imperfect surface
7 through which the optical communications signal is to pass; and
8 a flexible optically translucent sheet of material that is applied over
9 the area occupied by the void-filling material so as to capture the void-
10 filling material between an inside surface of the flexible optically
11 translucent sheet of material and the first imperfect surface of the window,
12 wherein the void-filling material is selected to have an index of
13 refraction that substantially matches an index of refraction for the window
14 at an optical wavelength corresponding to the free-space optical
15 communication signal.

1 37. The apparatus of claim 36, wherein the void-filling material
2 comprises a liquid.

1 38. The apparatus of claim 36, wherein the void-filling material
2 comprises a gel.

1 39. The apparatus of claim 36, wherein the window further
2 comprises a second imperfect surface including a plurality of non-flat
3 surface voids to which the void-filling material is also applied so as to fill

4 any non-flat surface voids in an area on the second imperfect surface
5 through which the optical communications signal is to pass, further
6 comprising:
7 a second flexible optically translucent sheet of material that is
8 applied over the area occupied by the void-filling material on the second
9 imperfect surface so as to capture the void-filling material between an
10 inside surface of the second flexible optically translucent sheet of material
11 and the second imperfect surface of the window.

1 40. The apparatus of claim 36, wherein the wavelength of the free-
2 space optical communications signal is from 700 to 1700 nanometers.